

Eight *Caloplaca* species newly recorded from Bolivia, including *C. crocina* comb. nov.

KARINA WILK* & ADAM FLAKUS

Laboratory of Lichenology, W. Szafer Institute of Botany, Polish Academy of Sciences,
Lubicz 46, Kraków PL–31–512, Poland

* CORRESPONDENCE TO: k.wilk@botany.pl

ABSTRACT—Eight species of *Caloplaca* s. lat. are reported as new to Bolivia: *Caloplaca baueri*, *C. cinnabarina*, *C. crocina*, *C. darbishirei*, *C. ochraceofulva*, *C. squamosa*, *C. subsoluta*, and *C. texana*. *Caloplaca texana* is also reported as new for Peru and the Southern Hemisphere. The new combination *Caloplaca crocina* is proposed and compared with other *Caloplaca* spp. producing hourglass-shaped ascospores. Taxonomic notes and data on the distribution and habitat preferences are presented for all treated species.

KEY WORDS—lichenized fungi, Ascomycota, Lecanoromycetes, Teloschistaceae, tropical dry forest

Introduction

Classification of the family *Teloschistaceae* has been the subject of intensive research over the last few years (e.g. Gaya et al. 2012, Arup et al. 2013, Kondratyuk et al. 2013). In the modern classification proposed by Arup et al. (2013), 39 genera in *Teloschistaceae*, with more than 1000 species estimated. The former *Caloplaca*, the most species-rich genus within *Teloschistaceae*, has been split into many genera based on phylogenetic DNA analyses. Research on *Teloschistaceae* systematics is still in progress and authors themselves (Arup et al. 2013, Kondratyuk et al. 2013) agree that the taxonomy is still not settled. As South American *Caloplaca* species are poorly known, especially at the molecular level, we decided not to apply the new systematics in the current paper and temporarily retain the species in *Caloplaca* s. lat. (see also note in Materials & methods).

Teloschistaceae are represented by five genera in Bolivia: *Caloplaca*, *Josefpoeltia*, *Teloschistes*, *Xanthomendoza*, and *Xanthoria* (Feuerer 2015). Only six *Caloplaca* taxa have been reported from the country: *C. brebissonii* (Fée) J. Sant. ex Hafellner & Poelt [= *Lecanora brebissonii*], *C. cerina* var. *chloroleuca* (Sm.) Th. Fr., *C. cirrochroa* (Ach.) Th. Fr. [= *Placodium cirrochroum*], *C. crocea* (Kremp.) Hafellner & Poelt subsp. *crocea* [also as *Callophisma xanthaspis*], *C. holocarpa* (Ach.) A.E. Wade s. lat. [also as *Lecanora pyracea*], and *C. quadrilocularis* (Nyl.) Zahlbr. [= *Lecidea quadrilocularis*] (Nylander 1859, 1861; Malme 1926; Hafellner & Poelt 1979; Feuerer et al. 1998; Rodriguez Flakus et al. 2014). There are a few South American countries in which the knowledge of *Caloplaca* is relatively comprehensive, e.g., Argentina (57 species), Brazil (52), Chile (45), and Uruguay (30) (Feuerer 2015). Based on checklists by Feuerer (2015), there are c. 140 *Caloplaca* species in all of South America.

Caloplaca s. lat. is fairly well understood in Europe, Asia, North America, Australasia, and both polar regions, while it remains poorly understood in Africa and South America. However, data on South American *Caloplaca* are included in several taxonomic studies (e.g., Zahlbruckner 1917, 1924; Malme 1926, Magnusson 1950; Hafellner & Poelt 1979; Kärnefelt 1990; Wetmore & Kärnefelt 1998, 1999; Kärnefelt et al. 2002; Scutari et al. 2002; Rosato & Arup 2010; Lumbsch et al. 2011; Söchting & Sancho 2012; Vargas Castillo & Beck 2012; Kondratyuk et al. 2014; Söchting et al. 2014), regional floristic surveys (e.g. Nylander 1859, 1861; Zahlbruckner 1933; Dodge 1936; Follmann 1967; Osorio 1983; Feuerer et al. 1998; Aptroot 2015), and checklists (e.g. Calvelo & Liberatore 2002). The work by Malme (1926) deserves special attention, since it includes descriptions of 34 South American species and a key for their identification.

This study is part of a project concerning the taxonomic evaluation of the genus *Caloplaca* s. lat. in Bolivia. Our main purpose is to determine taxonomic diversity and phylogenetic relationships of recognized species. We also intend to analyze the distribution and habitat preferences of individual species.

This paper covers eight species of *Teloschistaceae* newly recorded for Bolivia: *Caloplaca baueri*, *C. cinnabarina*, *C. crocina*, *C. darbishirei*, *C. ochraceofulva*, *C. squamosa*, *C. subsoluta*, and *C. texana*. *Caloplaca texana* is also reported as new to Peru and the Southern Hemisphere. *Caloplaca crocina* is compared with eight *Caloplaca* species producing ascospores with thickened spore walls: *C. calcitrapa*, *C. cupulata*, *C. dichroa*, *C. haematommona*, *C. lobulascens*, *C. pollinii*, *C. rheinigera*, and *C. yuennana*. Taxonomic notes and data on the distribution and habitat preferences for all eight species are presented.

Materials & methods

COLLECTIONS—The authors examined their own collections and herbarium specimens from B, KRAM, LD, MEL, S. Both authors collected specimens in the years 2004–15 throughout Bolivia (depts.: Beni, Chuquisaca, Cochabamba, La Paz, Potosí, Santa Cruz, Tarija) in the following vegetation zones (Ibisch & Mérida 2004): high mountain vegetation, Tucumano-Boliviano montane forest, semi-desert Inter-Andean Valleys, Chaqueño and Chiquitano dry forests, savanna Moxos, and anthropogenic woodlands. Flakus also collected some material from Colca Valley, Peru. The voucher specimens are available at KRAM and/or LPB.

MORPHOLOGICAL EXAMINATION—The materials were studied using standard microscopic techniques. Macro-morphological characters were measured from dry material. Hand-cut sections and squash preparations mounted in water were examined and measured microscopically, and the granulation of anatomical structures was observed in polarized light. Solubility of granules/crystals and color reactions were determined using 25% KOH (K) and 65% nitric acid (N). Hydrochloric acid (HCl) was used to test the presence of calcium carbonate (CaCO_3) in the substrate.

NOMENCLATURE—In the most recent classification of *Teloschistaceae*, Arup et al. (2013) and Kondratyuk et al. (2013) transferred five species treated here to new genera: *Caloplaca darbishirei* to *Austroplaca* Søchting et al.; *C. squamosa* and *C. subsoluta* to *Squamulea* Arup et al.; *C. texana* to *Wetmoreana* Arup et al.; and *C. cinnabarina* to *Brownliella* S.Y. Kondr. The other three featured species and some other species discussed here do not have modern recombinations.

New combination

Caloplaca crocina (Kremp.) K. Wilk & R. Vargas, **comb. nov.**

PLATE 1

MYCOBANK MB 816545

≡ *Lecidea crocina* Kremp., Flora 61: 519. 1878.

TYPE: Argentina, 1873–1874, Lorentz & Hieronymus (M!, **holotype**).

≡ *Blastenia crocina* (Kremp.) Müll. Arg., Rev. Mycol. (Toulouse) 10: 68. 1888.

≡ *Lecanora crocina* (Kremp.) Stizenb., Ber. Thätigk. St.

Gallischen Naturwiss. Ges. 1893–94: 235. 1895.

≡ *Calloppisma crocinum* (Kremp.) Malme, Ark. Bot. 20A(9): 19. 1926.

≡ *Placodium crocinum* (Kremp.) Räsänen, Borbásia 1: 129. 1939.

“*Caloplaca crocina*” Marcelli (as “*crocinum*”), nom. inval.

THALLUS not or sometimes slightly parasitized, thin to endophloeic, or thick, 60–150 μm thick; crustose, continuous to rimose, forming irregular patches, creamy, sometimes with greenish tinge, epruinose, smooth to slightly rough (when parasitized); vegetative propagules absent; prothallus usually present, conspicuous, black. **CORTEX** poorly developed, amorphous, hyaline, anthraquinones absent, K–, N–; algal layer discontinuous, algae concentrated

in groups. APOTHECIA always present, abundant, scattered or crowded in small groups of 2–3, round, angular or flexuous when compressed, adnate, zeorine to almost biatorine, 0.1–1.0(–1.4) mm wide; disc first concave, then $\pm$ plane, rarely slightly convex in old apothecia, orange to brownish orange or olive; proper margin swollen and prominent in young apothecia, then thinning and only slightly prominent, yellow orange, often contrasting against the disc, epruinose; thalline margin conspicuous or inconspicuous to almost absent, in young apothecia hidden at base of apothecia or invisible, in mature and old apothecia generally better developed, although often remaining $\pm$ hidden at base of apothecia, fragmented (as tiger stripes). PARATHECIUM thick, ≤ 200 μm , prosoplectenchymatous and composed of irregularly orientated hyphae (chondroid hyphae), anthraquinones present; amphitheciium usually strongly reduced, algae scarce and in distinct groups (only occasionally abundant), cortex absent or amorphous, anthraquinones absent; epihymenium yellow red or yellow brown, granular (anthraquinones), K+ purple; hymenium (65–)75–100(–120) μm thick; hypothecium yellowish or pale brownish, K–, oil droplets present or absent, prosoplectenchymatous, stipe present. PARAPHYSES simple or forked, 1.5–2.0 μm broad with upper cell not or slightly wider, 2–3 μm , oil droplets absent. ASCI 8-spored. ASCOSPORES hyaline, hourglass-shaped, 15–24 $\times$ 7–10(–13) μm , septum (3–)4–5(–6) μm , apical spore walls 1.5–3.0 μm .

PYCNIDIA not observed.

SPECIMENS EXAMINED: *Caloplaca crocina*—BOLIVIA. **DEPT. BENI**, Prov. Ballivian: near Reyes village, Moxos savanna, 14°18'10"S 67°18'49"W, alt. 192 m, on tree bark, 29 Nov. 2004, Wilk 2507 (KRAM), Flakus 4380 (KRAM, LPB), and 5 Dec 2004, Wilk 2320 (KRAM, LPB); Reyes village, 14°17'54"S 67°20'05"W, alt. 189 m, on wooden fence, good insolation, 29 Nov. 2004, Wilk 2332 (KRAM). **Prov. Cercado**, Trinidad, Missones Guarayos, alt. 250 m, Sept. 1926, E. Werdermann 2490 (S, B). **DEPT. LA PAZ**, **Prov. Franz Tamayo**, Parque Nacional y Área Natural de Manejo Integrado Madidi, Mojos, along the path to Virgen del Rosario, 14°33'22"S 68°52'27"W, alt. 1635 m, submontane anthropogenic woodlands, sunny and dry place, 31 Oct. 2007, Wilk 9356, 9380 (LPB), 9367, 9370, 9478 (KRAM). **DEPT. SANTA CRUZ**, **Prov. Cordillera**, Parque Nacional y Área Natural de Manejo Integrado Kaa-Iya del Gran Chaco: gasoducto Bolivia-Brasil, between Tucavaca colony and National Park border, 18°31'40"S 60°41'26"W, alt. 314 m, Chiquitano forest, 4 Dec. 2010, Flakus 19218 (KRAM, LPB); gasoducto Bolivia-Brasil KP 164, 60 km of Tucavaca colony, 18°27'29"S 61°23'01"W, alt. 292 m, Chaqueño forest, 3 Dec. 2010, Flakus 18960 (LPB), 18961 (KRAM); Charrata village near campamento de guardaparques, 18°28'05"S 62°05'43"W, alt. 307 m, Chaqueño forest, 2 Dec. 2010, Flakus 20144 (KRAM, LPB). **Prov. Chiquitos**, near Santa Cruz de la Vieja, mirador a San José de Chiquitos village, 17°52'21"S 60°45'41"W, alt. 501 m, Cerrado de la Chiquitanía (wooded savannas), 5 Dec. 2010, Flakus 19280 (LPB). **DEPT. TARIJA**, **Prov. Aniceto Arce**, Serranía de Propiedad Arnold, 22°13'19"S 64°33'41"W, alt. 1309 m, Tucumano-Boliviano montane forest, 24 Dec. 2010, Flakus 18866/1 (LPB). **DEPT. CHUQUISACA**, **Prov. Luis Calvo**, Parque Nacional y Área Natural de Manejo Integrado Serranía del

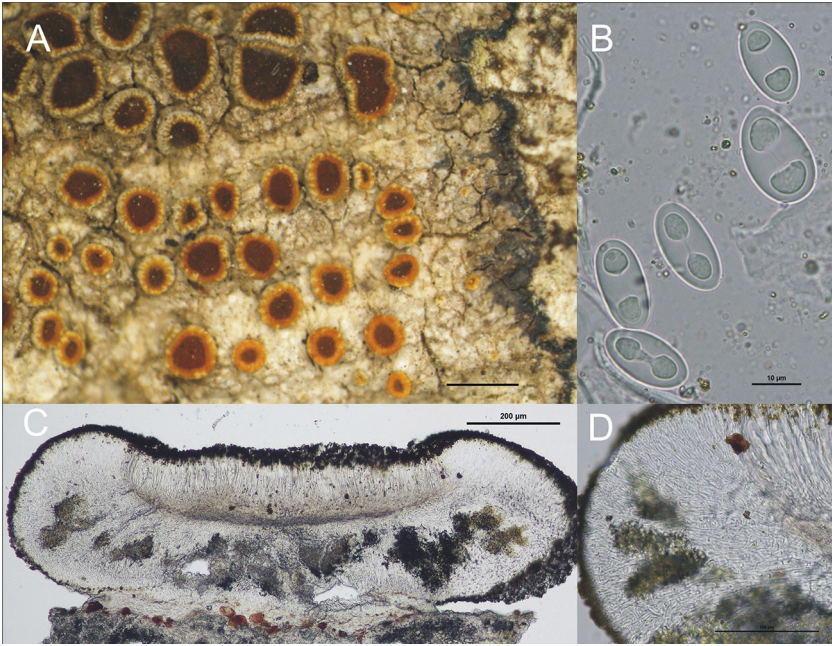


PLATE 1. *Caloplaca crocina*: A—habit (Wilk 2507, KRAM); scale bar= 1 mm. B—ascospores (Wilk 9380, LPB); scale bar= 10 μ m. C—vertical section of apothecium (Wilk 9478, KRAM); scale bar= 200 μ m. D—prosoplectenchymatic parathecium with irregularly orientated hyphae (Wilk 9380, LPB); scale bar= 100 μ m.

Iñaño, close to Ticucha, 19°37'26"S 63°50'55"W, alt. 1040 m, disturbed Sub-Andean Boliviano-Tucumano forests with Acacia, 18 July 2015, Flakus 26310 (KRAM, LPB). ARGENTINA. PROV. CORRIENTES, Dept. Concepción, 11 km N de Santa Rosa, 24 Jan. 1974, M.M. Arbo 504 (S).

Caloplaca letrouitioides—AUSTRALIA. VICTORIA, Gippsland Plain, Gunnamatta Beach, 1976, R.B. Filson 15871 (MEL, holotype).

COMMENTS—The combination *Caloplaca crocina* was suggested by Marcelli in the original version (dated 2002, unpublished) of the Brazil lichen checklist, as “*Caloplaca crocinum* [sic] (Krempelhuber) não comb. [i.e., not combined]”. After checking subsequent Marcelli publications and making wide enquiries amongst lichenologists in South America and internationally, we have found no evidence that this name was ever validated; Feuerer (2015) cited the species only as *Blastenia crocina*.

Caloplaca crocina is diagnosed by its continuous to rimose creamy thallus, zeorine apothecia with orange discs, and hourglass-shaped ascospores [sensu

Navarro-Rosinés et al. 2000; spore walls 1–2(–3) μm thick]. The apothecial thalline margin is usually much reduced and its fragments are visible at the base of apothecia. In contrast, the proper margin is thick and swollen, similar to that of the biatorine apothecia in *Letrouitia*. *Caloplaca crocina* is superficially very similar to *Letrouitia*, which differs in its multi-septate to muriform spores. Two other *Caloplaca* species resemble *Letrouitia* spp.: *Caloplaca letrouitioides* S.Y. Kondr. et al. and *C. kiewkaensis* Yakovczenko et al. (Kondratyuk et al. 2011). *Caloplaca letrouitioides* differs from *C. crocina* in having truly biatorine apothecia with a more swollen proper margin that partially overlaps the disc, apothecial discs at first distinctly concave, and thin-walled ascospores. *Caloplaca kiewkaensis* is distinguished by its smaller ellipsoid to almost spherical spores, a parathecium consisting of radiating hyphae, and a different Far East Russian distribution. See TABLE 1 for a comparison of *C. crocina* with *Caloplaca* species characterized by thick-walled ascospores—*C. calcitrata* Nav.-Ros. et al., *C. cupulata* Poelt & Hinter., *C. dichroa* Arup, *C. haematommona* Elix & S.Y. Kondr., *C. lobulascens* Poelt & Hinter., *C. pollinii* (A. Massal.) Jatta, *C. rheinigera* Elix & S.Y. Kondr., and *C. yuennana* (Zahlbr.) Poelt & Hinter.

In Bolivia, *C. crocina* occurs mainly on tree bark (rarely on wood) in savannas and relatively dry woodlands (e.g., Chaqueño and Chiquitano forests, Tucumano-Boliviano forest, and submontane anthropogenic woodlands) at altitudes between 190 and 1635 m. The species is very frequent in these areas. *Caloplaca crocina* occurs in subtropical and tropical regions of Argentina, Brazil, Paraguay (Malme 1926) and Uruguay (Osorio 1972). This is the first report from Bolivia.

Other species

Caloplaca baueri (Müll. Arg.) Zahlbr., Denkschr. Kaiserl. Akad. Wiss., Wien, Math.-Naturwiss. Kl. 83: 192. 1909.

SPECIMENS EXAMINED: *Caloplaca baueri*—BOLIVIA. DEPT. BENI, Prov. Itenez, Cerro de Oricore by Río San Martín, 13°19'55"S 63°30'37"W, alt. 240 m, dry forest overgrow granitic hill (an inselberg), 19 Aug. 2008, Flakus 12680/1 & Rodríguez (KRAM, LPB). DEPT. LA PAZ, Prov. Muñecas, Camata village, NE slope, 15°14'34"S 68°45'06"W, alt. 2020 m, open place, on a stone fence, 15 May 2006, Wilk 4436 (KRAM).

Caloplaca subunicolor—BRAZIL. MATTO GROSSO, pr. Cuyaba, 6 June 1894, G. Malme (LD 1036560).

Caloplaca baueri belongs to the *C. cinnabarina* group (Wetmore & Kärnefelt 1999). It is characterized by its continuous to rimose or only slightly areolate, smooth and glossy, greenish-yellow to yellow-orange thallus that gradually thins at the margin, with a minimal yellow prothallus. Apothecia are frequent. The

TABLE 1. Comparison of *Caloplaca crocina* and other *Caloplaca* spp. that produce thick-walled ascospores with $\pm$ reduced lumens (including typical hourglass-shaped spores)

CHARACTERS	<i>crocina</i>	<i>calcitrapa</i>	<i>cupulata</i>	<i>dichroa</i>
SPORES (μm)	15–24 $\times$ 8–11	11.5–15 $\times$ 6–8	16–21 $\times$ 8–13	12–16.5 $\times$ 6–8.5
SEPTUM (μm)	4–9	3–6	4–7	2.5–4
WALL (μm)	1.5–2.5	1–2	Unknown	1–2
APOTHECIA	Zeorine	Zeorine	Zeorine	Zeorine
DISC	Brownish orange	Orange	Brownish to red-orange	Orange
PROP MARGIN	Orange	Orange	Orange	Orange
K RXN	+, purple	+, purple	Unknown	+, purple
THAL MARGIN	+, $\pm$ fragmented near base	+	+	+
EXCIPLE	Parathecium, thick	Parathecium	Parathecium	Parathecium
PLECTENCHYMA	Prosop-	—	Para-	—
HYPH. ORIENT	Irregular	Radiating	—	Radiating thick-w
AMPHITHECIUM	Weakly dev.	+	+	+
ALGAE	Distinct groups	Abundant	Abundant	Abundant
THALLUS	Creamy	Yellow-orange,	White	Yellow to orange
K RXN	K–	K+ purple	K–	K+ purple
MORPHOLOGY	Continuous to rimose	Granulose-areolate	Granulose-areolate to squamulose	Areolate, with blastidia
SUBSTRATE	Bark (rarely wood)	Calcareous rocks	Bark, wood	Calcareous rocks
HABITAT	Dry woodland	Medit. vegetation	Arid forests	Sun-exposed sites
DISTRIBUTION	SAM—Argentina Bolivia Brazil Paraguay Uruguay	EUR—France Spain Italy; AFR—Algeria Morocco	Nepal	Europe
REFERENCES	Malme (1926); this paper	Navarro-Rosinés et al. (2000)	Poelt & Hinteregger (1993)	Arup (2006)

(concluded on p. 132)

Table 1, concluded

CHARACTERS	<i>haematommona</i>	<i>lobulascens</i>	<i>pollinii</i>	<i>rheinigera</i>	<i>yuennana</i>
SPORES (µm)	10–13 × 5–7	9–14 × 5–7	12.5–17 × 7–10	15–19 × 7–9	21–30 × 11–14
SEPTUM(µm)	4–6	2–5	4–7	3–7	3–5
WALL (µm)	c. 1	Unknown	c. 1	1–2	unknown
APOTHECIA	Biatorine (occ. zeorine)	Zeorine	Biatorine	Biatorine	Biatorine (occ. zeorine)
DISC	yOr to brOr	Orange-brown	Brwn/rust/blk	Rust-brown	Olive-black
PROP MARGIN	yOr to brOr	Orange-brown	Brwn/rust/blk	Rust-brown	Red-brown
K RXN	+ purple	Unknown	+ rViol > prp	Red-violet	Unknown
THAL MARGIN	Very thin/ —	+/evanescent	—	—	—/+ at base
EXCIPLE	Parathecium	Parathecium	Parathecium	Parathecium	Parathecium
PLECTENCH.	Para-	Para-	—	—	—
HYPH. ORIENT	Conglut. matrix	—	Radiating, thick-walled	Radiating, conglut.	Radiating
AMPHITHEC.	+/-	+	-	-	- (rarely +)
ALGAE	—	Abundant	—	—	(few below)
THALLUS	Whitish	Whitish	Grey	Grey	brW
K RXN	Unknown	Unknown	K-	Unknown	Unknown
MORPH.	Continuous, very thin to almost absent	Rimose- areolate, + phyllidia	Continuous to areolate	Continuous	Continuous to areolate
SUBSTRATE	Bark on shrub twigs	Siliceous rock	Bark, wood	Bark on twigs	<i>Picea</i> bark
HABITAT	Dry woodland	Warm temperate	—	Dry woodland	Temperate mixed forest
DISTRIBUTION	Australia	Nepal	Eur NAM Asia	Australia	China
REFERENCES	Kondratyuk et al. 2007	Poelt & Hinteregger 1993	Wetmore 1994	Kondratyuk et al. 2007	Poelt & Hinteregger (1993)

species resembles the European *C. ochracea* (Schaer.) Flagey, which produces spores with four locules, non-corticate thallus, and a habit on calcareous rocks. *Caloplaca baueri* is very similar to *C. subunicolor* (Nyl.) Zahlbr., which differs in having a more areolate, darker orange thallus and lack of prothallus; the geographical distribution of both species is also quite different, as *C. subunicolor* is centered in Africa (Wetmore & Kärnefelt 1999). Moreover, *C. baueri* may also be confused with *C. cinnabarina*, which has a distinctly areolate bright orange thallus with elongated areoles at the thallus margin. Wetmore & Kärnefelt (1999) and Wetmore (2007) provide a detailed description of *C. baueri*.

The species occurs in Bolivia on silicate outcrops in dry forest, surrounded by the humid Amazonian zone. *Caloplaca baueri* is known from Central and South America, and the Caribbean region; in South America Wetmore & Kärnefelt (1999) have reported *C. baueri*; this is the first report from Bolivia.

***Caloplaca cinnabarina* (Ach.) Zahlbr., Nat. Pflanzenfam., 1(1*): 228. 1908.**

EXSICCATI EXAMINED—Wetmore, Telos. Exsicc. 28, 29 (KRAM). Weber, Lich. Exs. 446 (as *Caloplaca subnitida*) (KRAM).

SPECIMENS EXAMINED—BOLIVIA. DEPT. LA PAZ, Prov. Franz Tamayo, Parque Nacional y Área Natural de Manejo Integrado Madidi, along the way from Mojos to Insensio, 14°33'22"S 68°52'27"W, alt. 1635–1960 m, sunny, dry area with sparse trees and shrubs, 1 Nov. 2007, Wilk 9545 (KRAM, LPB). DEPT. SANTA CRUZ, Prov. Chiquitos, near Santa Cruz de la Vieja, mirador a San José de Chiquitos village, 17°52'21"S 60°45'41"W, alt. 501 m, Cerrado de la Chiquitanía (wooded savannas), 5 Dec. 2010, Flakus 19376, Quisbert & Wolski (KRAM, LPB). AUSTRALIA. NEW SOUTH WALES, 'Bush Bottoms', NE of Goulburn, 18 Oct. 1987, H. Streimann 38875 (B).

Caloplaca cinnabarina is characterized by its bright orange areolate thallus with the areoles slightly elongated at the thallus margin. The apothecia are more or less immersed in and concolorous with the thallus. See Wetmore & Kärnefelt (1999), Wetmore (2007) and Joshi et al. (2011) for detailed descriptions. To distinguish *C. cinnabarina* from *C. baueri* see remarks above under that species. The recently described Australian species, *C. brownlieae* S.Y. Kondr. et al., differs from *C. cinnabarina* in having a dull pink to dull brownish-orange thallus and wider paraphyses tips, ascospores, and spore septa. According to Lumbsch et al. (2011), *C. brownlieae* also differs chemically in having ovoic and lecanoric acids and a high concentration of gyrophoric acid. *Caloplaca rubelliana* (Ach.) Lojka, a primarily European species, is very similar to *C. cinnabarina*, but is distinguished by its greyish-orange or brownish-orange thallus that thins at the margin and scarlet red apothecia; moreover, it does not form elongated areoles at the thallus margin (Wetmore & Kärnefelt 1999).

Caloplaca cinnabarina occurs in Bolivia on silicate rocks in dry woodland areas. This rather well known species, widespread in subtropical and tropical

regions, has been reported from North and Central America (Wetmore & Kärnefelt 1999), Africa (Kärnefelt 1988), Australia (Kärnefelt 2003), New Zealand (Galloway 2007), and Asia (Joshi et. al. 2010). In South America it is known from Argentina (Calvelo & Liberatore 2002), Uruguay (Osorio 1983) and Venezuela (Aptroot 2015). This is the first report from Bolivia.

Caloplaca darbshirei (C.W. Dodge & G.E. Baker) Cretz., Bul. Gräd. Bot. Univ. Cluj 21: 140. 1941.

SPECIMEN EXAMINED—BOLIVIA. DEPT. POTOSI, Prov. Nor Lipez, Pinturas Rupestres near Mallku Villamar village, 21°46'20"S 67°29'05"W, alt. 4038 m, high Andean area, 6 Dec. 2009, Flakus 14802 (LPB).

The species is characterized by its orange-yellow, squamulose, and sorediate thallus. The squamules are peltate with incised margins, and the soralia develop on the underside of the squamule margins. Soredia are concolorous with the thallus. The closely related *Caloplaca soropelta* (E.S. Hansen et al.) Søchting differs in its less incised squamule margins and golden yellowish soredia distinctly lighter than the thallus. For more information about both species see Søchting & Castello (2012).

Caloplaca darbshirei occurs in Bolivia on silicate rock together with *C. texana* in high montane regions. It is known from Antarctica and the southernmost part of Argentina in South America (Søchting & Castello 2012). This is the first report of *C. darbshirei* from Bolivia.

Caloplaca ochraceofulva (Müll. Arg.) Jatta, Nouv. Giorn. Bot. Ital., n.s. 17: 194. 1910.

EXSICCATI EXAMINED—Almborn, Lich. africani 69 (as *C. subnitida*) (LD).

SPECIMENS EXAMINED: *Caloplaca ochraceofulva*—BOLIVIA. DEPT. LA PAZ, Prov. Bautista Saavedra, Charazani village, alt. c. 3000 m, by the road, open place, 13 May 2006, Wilk 4144 (KRAM). DEPT. COCHABAMBA, Prov. Quillacollo, area of Inkarraya-Sipesipe, semidesert Inter-Andean Valleys, 17°29'25"S 66°22'09"W, alt. 3146 m, rocky and shrubby slope, sunny place, E exp., 17 Dec. 2004, Wilk 3277 (KRAM, LPB). ARGENTINA. PROV. JUJUY, Santa Barbara, alt. 1300 m, 9 July 1901, Rob. E. Fries 50 (LD).

Caloplaca isidiosa—BRAZIL. BAHIA, zwischen Feira de Santana und Milagres, alt. 200 m, an bodennahen Granitblöcken in einer Caatinga, 21 July 1980, K. Kalb [Lichenes neotropici no. 207] (B).

Caloplaca ochraceofulva is characterized by its placodioid thallus with moderately long and flat lobes. The central thallus is rimose-areolate, with numerous isidia produced on the margins of rather thick subsquamulose areoles. The species usually occurs in the sterile form. For more information see Malme (1926, as *C. subnitida*), Kärnefelt (1990) and Wetmore & Kärnefelt (1998). The similar

C. texana differs in having the central thallus densely covered by phyllidia. *Caloplaca ochraceofulva* may also be confused with *C. isidiosa* (Vain.) Zahlbr., which is distinguished by its coralloid or simple elongate isidia that densely cover the central thallus and frequent apothecia (Kärnefelt 1988, 1990).

Caloplaca ochraceofulva occurs in Bolivia on silicate or slightly calcareous rocks in high Andean regions at an altitude of c. 3000 m. It has an African-South American distribution pattern (Kärnefelt 1988) and has been recorded from Argentina (Malme 1926), Brazil (Osorio & Fleig 1990), Peru (Ramos 2014), and southern and eastern Africa, including one locality on the Arabian Peninsula (Kärnefelt 1990). This is the first report from Bolivia.

Caloplaca squamosa (B. de Lesd.) Zahlbr., Cat. Lich. Univ. 10: 629. 1940.

EXSICCATI EXAMINED—Weber, Lich. Exs. Colo. 414 (as *Caloplaca modesta*) (KRAM).

SPECIMEN EXAMINED—BOLIVIA. DEPT. SANTA CRUZ, Prov. Caballero, area of Siberia village, 17°49'38"S 64°45'14"W, alt. 3480 m, the field on hill above road (on the fringes of the Yungas cloud forest), open, foggy and windy area, on sandstone, 15 Dec. 2004, Wilk 3049 (KRAM, LPB), 3073, 3125 (KRAM).

Caloplaca squamosa and *C. subsoluta* (discussed below) belong to the *C. squamosa* group, which is characterized by a more or less squamulose thallus, orange apothecia, and a paraplectenchymatous apothecial proper margin (Wetmore 2003). Both *C. squamosa* and *C. subsoluta* are highly variable and more study is needed to refine their taxonomy. Typical *C. subsoluta* differs from *C. squamosa* by its areolate to subsquamulose thallus lacking short lobes and smaller apothecia lacking distinct thalline margins. For more information on both species see Wetmore (2003, 2007).

Caloplaca squamosa occurs in Bolivia on silicate rocks in open anthropogenic areas close to Yungas cloud forest at an altitude of c. 3000 m. Its centre of distribution lies in southwestern North America (Wetmore 2003, 2007). In South America it is known from the Galapagos Islands (Bungartz et al. 2013). This is the first report from Bolivia.

Caloplaca subsoluta (Nyl.) Zahlbr. s. lat., Cat. Lich. Univ. 7: 185. 1931.

EXSICCATI EXAMINED—Wetmore, Telos. Exsicc. 71, 72, 73, 92 (KRAM). Suza, Lich. Bohemoslov. 206 (as *C. irrulescens*) (KRAM).

SPECIMENS EXAMINED—BOLIVIA. DEPT. SANTA CRUZ, Prov. Caballero, area of Siberia village, 17°49'38"S 64°45'14"W, alt. 3480 m, a field on hill above road (on the fringes of the Yungas cloud forest), open, foggy and windy area, 15 Dec. 2004, Wilk 3134 (KRAM, LPB). DEPT. COCHABAMBA, Prov. Quillacollo, area of Inkarraya-Sipesipe, 17°29'25"S 66°22'09"W, alt. 3146 m, semidesert Inter-Andean Valleys, rocky and shrubby slope, sunny place, E exp., 17 Dec. 2004, Wilk 3228 (LPB). PERU. AREQUIPA, Prov. Caylloma, Valle del Colca valley, near Socorro village, 15°38'32"S 71°43'22"W, alt. 3349 m, open semi-desert montane area, 3 July 2006, Flakus 9409 & Cykowska (KRAM).

Wetmore (2003) also treats *Caloplaca subsoluta* in the *C. squamosa* group. The species, together with *C. americana* (Malme) Zahlbr., *C. irrubescens* (Arnold) Zahlbr., and *C. modesta* (Zahlbr.) Fink form a group of very similar species, but the taxonomic affiliation is unclear. The interpretation of these species varies according to author; for example, Wetmore (2003) treats *C. americana*, *C. irrubescens*, and *C. modesta* as synonyms of *C. subsoluta*. For comparison with *C. squamosa*, see comments above under that species.

Caloplaca subsoluta occurs in Bolivia on sandstone rocks in open anthropogenic areas at altitudes above 3000 m. The species is distributed worldwide and has been reported from Europe (e.g. Hafellner & Türk 2001), North America (Wetmore 2003), Asia (e.g. Joshi et al. 2010), and Africa (e.g. Fryday 2015). In South America it has been recorded from Argentina, Brazil (Malme 1926, as *Callophisma americanum*), Peru (Ramos 2014), Uruguay (Osorio 1983, as *Caloplaca americana*), Venezuela (Aptroot 2015), and the Galapagos Islands (Bungartz et al. 2013). This is the first report from Bolivia.

Caloplaca texana Wetmore & Kärnefelt. Bryologist 101(2): 247. 1998.

EXSICCATI EXAMINED—Wetmore, Telos. Exsicc. 8, 74, 75 (KRAM). Nash, Lich. Exs. 256 (KRAM).

SPECIMENS EXAMINED—BOLIVIA. DEPT. POTOSI, Prov. Nor Lipez, Pinturas Rupestres near Mallku Villamar village, 21°46'20"S 67°29'05"W, alt. 4038 m, high Andean area, 6 Dec. 2009, Flakus 14802/1 (KRAM), Flakus 14812 & Rodriguez (LPB). PERU. AREQUIPA, Prov. Caylloma, Valle del Colca valley, near Soccoro village, 15°38'32"S 71°43'22"W, alt. 3349 m, open semi-desert montane area, 3 July 2006, Flakus 9404, 9408, 9411, 9414, 9415 & Cykowska (KRAM).

Caloplaca texana is a distinctive species distinguished by its thick placodioid thallus that produces moderately long flat marginal lobes ±loosely attached to the substratum. The central thallus is areolate with numerous phyllidia. The species usually occurs in the sterile form. The similar *C. ochraceofulva* is distinguished by its globose isidia on the squamulose areole margins. *Caloplaca texana* may be confused with *C. appressa* Wetmore & Kärnefelt, which differs in its marginal lobes tightly appressed to the rock, frequent reddish apothecia, and lack of vegetative diaspores (Wetmore & Kärnefelt 1998).

Caloplaca texana occurs in Bolivia on silicate rocks in high montane areas at altitudes above 4000 m. It was originally described from North America, and these Bolivian and Peruvian records represent the first reports from the Southern Hemisphere.

Acknowledgements

We are grateful to Mark R.D. Seaward (Bradford, UK), Reinaldo Vargas Castillo (Santiago, Chile), and Shaun Pennycook for reviewing the manuscript and providing

important suggestions and improvements. We thank L. Śliwa and M. Piątek (Krakow, Poland) for constructive discussion on some taxonomic and nomenclatural issues, and A. Spielmann (Mato Grosso do Sul, Brazil) and A. Aptroot (Soest, Netherlands) for help in clarifying the *C. crocina* nomenclatural status. We thank the staff of the Herbario Nacional de Bolivia, Universidad Mayor de San Andrés (LPB), for collaboration and invaluable help during the field studies. The first author is also grateful to P. Jørgensen (St. Louis, MO, US) for the possibility to collaborate with the team working within the Madidi Project and to T. Wilk (Krakow, Poland) for assistance during the fieldwork. The second author wishes to thank P. Rodriguez Flakus (Krakow, Poland), J. Quisbert (La Paz, Bolivia), A. Wolski (Gliwice, Poland), and all protected areas staff for their kind help during the fieldwork. We thank the Curators of B, KRAM, LD, MEL, S for providing the material for study, and A. Aptroot (Soest, Netherlands), C. Wetmore (Minnesota, US) and R. Vargas Castillo (Santiago, Chile) for literature support. Financial support was provided to the first author by the National Science Centre (NCN, grant no. N N303 821740) and statutory funds by the W. Szafer Institute of Botany, Polish Academy of Sciences.

Literature cited

- Aptroot A. 2015. Holarctic and Caribbean crustose lichens collected by López Figueras in Venezuela. *Glalia* 7(1): 1–18.
- Arup U. 2006. A new taxonomy of the *Caloplaca citrina* group in the Nordic countries, except Iceland. *Lichenologist* 38: 1–20. <http://dx.doi.org/10.1017/S0024282905005402>
- Arup U, Søchting U, Frödén P. 2013. A new taxonomy of the family *Teloschistaceae*. *Nordic Journal of Botany* 31: 16–83.
- Bungartz F, Ziemmeck F, Yáñez Ayabaca A, Nugra F, Aptroot A. 2013. CDF Checklist of Galapagos Lichenized Fungi. In: F Bungartz et al. (eds.), Charles Darwin Foundation Galapagos Species Checklist. Charles Darwin Foundation, Galapagos. Last updated: 03 Dec 2013: <http://www.darwinfoundation.org/datazone/checklists/true-fungi/lichens/>
- Calvelo S, Liberatore S. 2002. Catálogo de los líquenes de la Argentina [Checklist of Argentinean Lichens]. *Kurtziana* 29(2): 7–170.
- Dodge CW. 1936. Lichens of the G. Allan Hancock expedition of 1934, collected by Wm. R. Taylor. *The Hancock Pacific Expeditions* 3(3): 33–46.
- Feuerer T (ed.). 2015. Checklists of lichens. Version 2015. Universität Hamburg. Viewed online on April 2016: <http://webapp5.rz.uni-hamburg.de/lichens/formular.php>
- Feuerer T, Ahti T, Vitikainen O. 1998. Lichenological investigations in Bolivia. 71–86, in: MP Marcelli, MRD Seaward (eds), *Lichenology in Latin America: history, current knowledge and applications*. Sao Paulo, CETESB.
- Follmann G. 1967. Die Flechtenflora der nordchilenischen Nebelose Cerro Moreno. *Nova Hedwigia* 14: 215–281.
- Fryday A. 2015. A new checklist of lichenised, lichenicolous and allied fungi reported from South Africa. *Bothalia* 45(1): Art. #148. 4 p. <http://dx.doi.org/10.4102/abc.v45i1.148>
- Galloway D. 2007. *Flora of New Zealand Lichens. Revised Second Edition including Lichen-Forming and Lichenicolous Fungi. Volumes 1 and 2.* Manaaki Whenua Press, Lincoln, New Zealand. i-cxxx + 2261 p.
- Gaya E, Högnabba F, Holguín Á, Molnar K, Fernández-Brime S, Stenroos S, Arup U, Søchting U, Boom P van den, Lücking R, Sipman HJM, Lutzoni F. 2012. Implementing a cumulative supermatrix approach for a comprehensive phylogenetic study of the *Teloschistales*

- (*Pezizomycotina*, *Ascomycota*). *Molecular Phylogenetics and Evolution* 63(2): 374–387. <http://dx.doi.org/10.1016/j.ympev.2012.01.012>
- Hafellner J, Poelt J. 1979. Die Arten der Gattung *Caloplaca* mit plurilocularen Sporen (*Meroplacis*, *Triophthalmidium*, *Xanthocarpia*). *Journal of the Hattori Botanical Laboratory* 46: 1–41.
- Hafellner J, Türk R. 2001. Die lichenisierten Pilze Österreichs - eine Checkliste der bisher nachgewiesenen Arten mit verbreitungangaben. *Stapfia* 76: 1–167.
- Ibisch PL, Mérida G. (eds) 2004. Biodiversity: The richness of Bolivia. State of knowledge and conservation. Editorial FAN, Santa Cruz de la Sierra, Bolivia.
- Joshi Y, Wang XY, Yamamoto Y, Koh YJ, Hur J-S. 2010. A first modern contribution to *Caloplaca* biodiversity in South Korea: two new species and some new country records. *Lichenologist* 42: 715–722. <http://dx.doi.org/10.1017/S0024282910000368>
- Joshi Y, Thüs H, Hur J-S. 2011. *Caloplaca aequata* is a synonym of *C. cinnabarina* (*Teloschistaceae*). *Lichenologist* 43: 141–146. <http://dx.doi.org/10.1017/S0024282910000812>
- Kärnefelt I. 1988. Morphology and biogeography of saxicolous *Caloplaca* in southern Africa. *Monographs in Systematic Botany from the Missouri Botanical Garden* 25: 439–452.
- Kärnefelt I. 1990. Isidiate taxa in the *Teloschistaceae* and their ecological and evolutionary significance. *Lichenologist* 22: 307–320. <http://dx.doi.org/10.1017/S0024282990000342>
- Kärnefelt I. 2003. Three species of *Caloplaca* in Australia with different reproductive models. 341–350, in: M Jensen (ed.), *Lichenological Contributions in Honour of G.B. Feige*. *Bibliotheca Lichenologica*, J. Cramer, Berlin, Stuttgart.
- Kärnefelt I, Kondratyuk S, Søchting U, Frödén P, Arup U. 2002. Two new species of *Caloplaca* (*Teloschistaceae*) from the Southern Hemisphere. *Bryologist* 105: 301–309. [http://dx.doi.org/10.1639/0007-2745\(2002\)105\[0301:TNSOCT\]2.0.CO;2](http://dx.doi.org/10.1639/0007-2745(2002)105[0301:TNSOCT]2.0.CO;2)
- Kondratyuk S, Kärnefelt I, Elix JA, Thell A. 2007. New species of the genus *Caloplaca* in Australia. 341–386, in: I Kärnefelt, A Thell (eds.), *Lichenological Contributions in Honour of David Galloway*. *Bibliotheca Lichenologica* 95. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Berlin-Stuttgart.
- Kondratyuk SY, Elix JA, Galanina IA, Yakovchenko LS, Kärnefelt I, Thell A. 2011. Four new *Caloplaca* species (*Teloschistaceae*, *Ascomycotina*). *Folia Cryptogamica Estonica* 48: 17–23.
- Kondratyuk SY, Jeong M-H, Yu N-N, Kärnefelt I, Thell A, Elix JA, Kim J, Kondratyuk AS, Hur J-S. 2013. Four new genera of teloschistoid lichens (*Teloschistaceae*, *Ascomycota*) based on molecular phylogeny. *Acta Botanica Hungarica* 55(3–4): 251–274. <http://dx.doi.org/10.1556/ABot.55.2013.3-4.8>
- Kondratyuk SY, Jeong M-H, Yu N-N, Kärnefelt I, Thell A, Elix JA, Kim J, Kondratyuk AS, Hur J-S. 2014. A revised taxonomy for the subfamily *Caloplacoideae* (*Teloschistaceae*, *Ascomycota*) based on molecular phylogeny. *Acta Botanica Hungarica* 56(1–2): 93–123. <http://dx.doi.org/10.1556/ABot.56.2014.1-2.10>
- Lumbsch HT et al. 2011. One hundred new species of lichenized fungi: a signature of undiscovered global diversity. *Phytotaxa* 18: 1–127. <http://dx.doi.org/10.11646/phytotaxa.18.1.1>
- Magnusson AH. 1950. Lichens from Uruguay. *Meddel. Goteborgs Bot. Tragard.* 18: 213–237.
- Malme GOA. 1926. Lichenes blasteniospori Herbarii Regnelliani. *Arkiv för Botanik* \Ark. Bot. 20A (9): 1–51.
- Navarro-Rosinés P, Gaya E, Roux C. 2000. *Caloplaca calcitrata* sp. nov. (*Teloschistaceae*) un nuevo liquen saxícola-calcícola mediterráneo. *Bulletin de la Société Linnéenne de Provence* 51: 145–152.
- Nylander W. 1859. Lichenes Exotici, Lichenes in regionibus exoticis quibusdam vigentes exponit synoptice enumerationibus. *Annales des Sciences Naturelles* 11: 205–264.

- Nylander W. 1861. Additamentum ad Lichenographiam Andium Bolivienis. Annales des Sciences Naturelles 15: 365–382.
- Osorio HS. 1972. Contribution to the lichen flora of Uruguay. VII. A preliminary catalogue. Comunicaciones Botanicas del Museo de Historia Natural de Montevideo 4(56): 1–46.
- Osorio HS. 1983. Contribution to the lichen flora of Uruguay XIX. Lichens from Rio de la Plata coast. Phytologia 54: 279–282.
- Osorio HS, Fleig M. 1990. Contribution to the lichen flora of Brazil. XXVII. Additions and corrections to the Rio Grande do Sul lichen flora. Comunicaciones Botanicas del Museo de Historia Natural de Montevideo 5(94): 1–6.
- Poelt J, Hinteregger E. 1993. Beiträge zur Kenntnis der Flechtenflora des Himalaya. VII. Die Gattungen *Caloplaca*, *Fulgensia* und *Ioplaca* (mit englischem Bestimmungsschlüssel). Bibliotheca Lichenologica 50: 247 p.
- Ramos D. 2014. Lista de especies de líquenes y hongos liquenícolas del Perú – Checklist of lichens and lichenicolous fungi of Peru. Glalia 6(2): 1–49.
- Rodriguez Flakus P, Flakus A, Kukwa M, Etayo J, Lücking R, Meneses RI, Rivas Plata E, Stanton D, Truong C, Vargas R. 2014. Preliminary catalogue of lichens and lichenicolous fungi from Bolivia. Version 1.4. (1 February 2014). W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow. <http://bio.botany.pl/lichens-bolivia/> (viewed online on January 2016).
- Rosato VG, Arup U. 2010. *Caloplaca austrocitrina* (Teloschistaceae) new for South America, based on molecular and morphological data. Bryologist 113: 124–128.
- Scutari N, Rosato V, Söchting U. 2002. *Caloplaca andina* comb. nov. (Teloschistaceae, Ascomycota), a species close to the genus *Fulgensia*. Mitteilungen aus dem Institut für Allgemeine Botanik in Hamburg 30-32: 213–224.
- Söchting U, Castello M. 2012. The polar lichens *Caloplaca darbishirei* and *C. soropelta* highlight the direction of bipolar migration. Polar Biology 35: 1143–1149. <http://dx.doi.org/10.1007/s00300-012-1161-z>
- Söchting U, Sancho LG. 2012. *Caloplaca magellanica* sp. nova, a southern Patagonian parasite on *Zahlbrucknerella*. Bibliotheca Lichenologica 108: 215–220.
- Söchting U, Søgaard MZ, Elix JA, Arup U, Elvebakk A, Sancho LG. 2014. *Catenarina* (Teloschistaceae, Ascomycota), a new Southern Hemisphere genus with 7-chlorocatenarin. Lichenologist 46(2): 175–187. <http://dx.doi.org/10.1017/S002428291300087X>
- Wetmore CM. 1994. The lichen genus *Caloplaca* in North and Central America with brown or black apothecia. Mycologia 86: 813–838. <http://dx.doi.org/10.2307/3760596>
- Wetmore CM. 2003. The *Caloplaca squamosa* group in North and Central America. Bryologist 106: 147–156. [http://dx.doi.org/10.1639/0007-2745\(2003\)106\[0147:TCSGIN\]2.0.CO;2](http://dx.doi.org/10.1639/0007-2745(2003)106[0147:TCSGIN]2.0.CO;2)
- Wetmore CM. 2007. *Caloplaca*. 179–220, in: TH III Nash, C Gries, F Bungartz (eds.). Lichen Flora of the Greater Sonoran Desert Region. Volume 3. Lichens Unlimited, Arizona State University, Tempe.
- Wetmore CM, Kärnefelt EI. 1998. The lobate and subfruticose species of *Caloplaca* in north and central America. Bryologist 101: 230–255. [http://dx.doi.org/10.1639/0007-2745\(1998\)101\[230:TCLASSO\]2.0.CO;2](http://dx.doi.org/10.1639/0007-2745(1998)101[230:TCLASSO]2.0.CO;2)
- Wetmore CM, Kärnefelt EI. 1999. What is *Caloplaca cinnabarina*?. Bryologist 102: 683–691. <http://dx.doi.org/10.2307/3244255>
- Vargas Castillo R, Beck A. 2012. Photobiont selectivity and specificity in *Caloplaca* species in a fog-induced community in the Atacama Desert, northern Chile. Fungal Biology 116: 665–676. <http://dx.doi.org/10.1016/j.funbio.2012.04.001>

- Zahlbruckner A. 1917. Botanische Ergebnisse der Schwedischen Expedition nach Patagonien und dem Feuerlande 1907–1909. VI. Die Flechten. Kongl. Svenska Vetenskaps-Akademiens Handlingar, Stockholm 57(6): 1–62.
- Zahlbruckner A. 1924. Die Flechten der Juan-Fernandez-Inseln. In: Skottsberg C. (ed.) *The Natural History of Juan Fernandez and Easter Island*. II, pp. 315–498.
- Zahlbruckner A. 1933. Líquenes del herbario del Museo Nacional de Santiago de Chile. *Revista Chilena de Historia Natural* 37: 165–170.